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# The Malleable Iron Industry

Lester E. Samstag, Met. E., 4

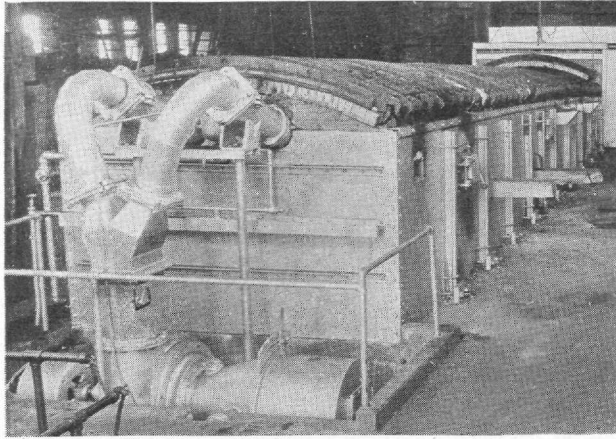


Figure 1

The mighty rearmament program of the United States is just starting to gather momentum. The industrial pulse of the nation has quickened and government orders are being meted out with seemingly reckless abandon. Each contract no matter how small, however, is a vital cog in the rolling wheels of our rearmament machine. Many and varied are the different industries which are supplying the demands of the government. The author will give his version of one of the smaller industries, namely the malleable iron industry.

Ever since Seth Boyden first manufactured malleable castings in 1826 in Newark, N. J., the industry has steadily advanced. At present there are about 140 malleable iron foundries in the United States producing about 400,000 tons of malleable castings per annum. Due to their unique qualities of strength, ductility, machineability, and resistance to shock malleable castings find a wide field of industrial applications. Malleable castings are used extensively in automobiles, agricultural equipment, plumbing equipment, railroad machinery, machine tools, household appliances and many other industries too numerous to mention here. Many important parts for the new trucks being manufactured for the government are made of malleable iron.

The malleable iron metallurgical process is conducted in two steps. The first step consists of making what is known as "hard iron" castings, in which all the carbon should be in the "combined" form. The second step consists of converting, through a proper heat treating cycle, these hard and brittle castings into an easily-machinable product, which while soft and ductible is surprisingly tough and strong.

The furnace charge from which malleable castings are to be made usually consists of a mixture of 30 to 40% of pig iron, 45 to 50% of sprues, or scrap from previous heats, and the balance of malleable scrap which is purchased or obtained from defective castings scrapped at the plant. At times a small amount of steel scrap is introduced, mainly for carbon adjustment. The charge will vary depending on the type of furnace used, and on the type of castings desired: either small or large and with high or low tensile properties. The charge is computed each day, and the constituents are carefully weighed up and placed in the furnace.

The air furnace is probably the most common furnace used for melting the charge to make "hard iron" castings. However the cupola, electric furnace, and open hearth furnace are also used to some extent. Figure 1 illustrates the type of air furnace used in the industry today. The furnace is fired with pulverized coal, which is blown in through the two inlet pipes shown in the picture. The furnace is lined with high-grade fire-clay brick, and the bung arches which form the roof space are removable so that the charge can be placed in the furnace. The projections on the side of the furnace are the tapping spouts through which the iron is discharged. The furnace shown here has a capacity of 40 tons.

The charge is introduced into the furnace and the melting process, the main function of which is simply to obtain a molten product, is started. There is little



Figure 2

attempt made to eliminate undesirable constituents, but there are oxidation losses of silicon, manganese, and iron, and slight increases in sulphur and phosphorus. In the malleable iron industry a great many castings of the same size are made and it is therefore important that the composition be carefully controlled. The composition of the iron is controlled by varying the amount of coal used, the amount of air blast, and by the use of ferro-alloys. The operator may also have reducing, neutral, or oxidizing conditions in the furnace as he sees fit.

The melting process takes about 12 hours in an average furnace of about 35 tons capacity. This time will vary with the type of furnace used and the temperature of the metal desired. If small castings are to be made, it is necessary to have the metal very hot. High temperatures make the iron fluid, and the metal must be very fluid in pouring small castings in order

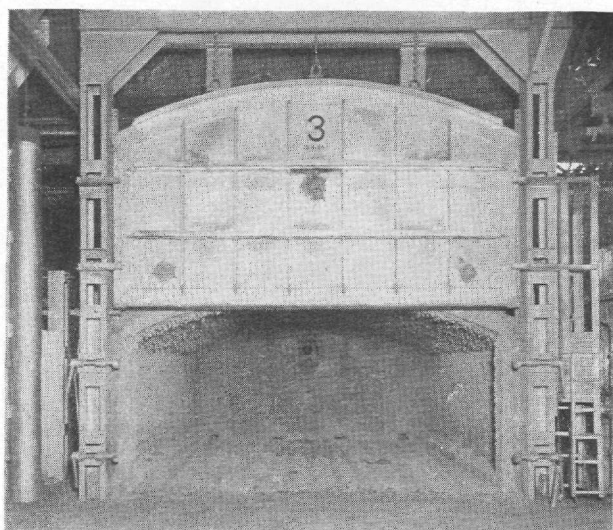


Figure 3

that it will reach the intricate portions of the mold, before it solidifies. Iron melts at about 2700° F. and has a temperature of about 2900° F. when it comes out of the furnace, representing a superheat of about 200° F. At regular intervals during the melting, test sprues are poured and broken. The furnace operator examines these, and can remedy any adverse conditions arising.

Let us now look at the preparation of the molds into which the molten iron is poured. In all foundry practice the mold is the essential feature. All molds are made from patterns which may be of wood or metal. The molds are supported by and enclosed in a flask, which may be of wood or metal also. The most common materials for molding are sand, either dry or green, loam, plaster of paris or iron. The iron molds are permanent molds. Cavities in the castings are formed by the use of cores, which are made of baked or green sand. When the iron is poured into the

mold it flows around the core and solidifies leaving a cavity in the casting. Molding operations are divided, the lighter castings being made by what is known as bench work and the heavier castings by floor work.

In molding, the sand is rammed up around the pattern, and the pattern is removed. The impression left in the sand represents the shape of the casting to be made. When the iron is poured into the mold it fills the impression, and the result is a "hard iron" casting. Figure 2 illustrates bench work molding very well. The man is setting his mold on the floor after having just completed molding it. The molding machine can be seen in the background.

The molds are poured either by the use of clay lined hand ladles for the smaller molds, or large crane-conveyed ladles for the larger molds. The hand ladles hold about 50 pounds of iron, while the larger ladles are made to hold several tons if necessary. The iron is conveyed to various parts of the foundry to supply the hand ladles. This is done with bull ladles which hold about 300 pounds of iron.

After the molds have been poured they are allowed to cool, and the castings solidify. The castings are removed from the sand and the feeders and gates are knocked off. This is easily possible because the hard iron is extremely brittle. The castings are then usually cleaned in tumbling barrels, although sand blasting is also used. The cleaned castings are inspected and the gates and fins trimmed off by grinding. The castings are then ready for the annealing ovens, where the second metallurgical step is accomplished.

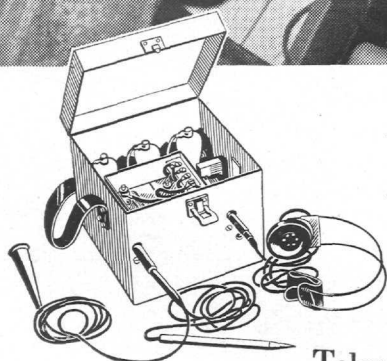
The hard iron castings are placed in cast iron pots and surrounded by a packing material. This packing material is generally crushed air furnace or blast furnace slag, although sand is sometimes used. The principal object of packing is to prevent the castings from warping during the annealing process. The packing material must have refractory properties so that it will not fuse on the castings at annealing temperatures.

When one pot has been filled, another pot is placed on top of it and filled in a similar manner, followed by a third and fourth. These pots are placed on a flat cast-iron stool, and constitute what is known as a stand. The joints between the pots are carefully luted with clay, and the stands are placed in the oven in rows. The average annealing oven can accommodate 4 rows 8 stands deep and still have suitable clearance between them for circulation. The oven door is then placed on and all openings are securely luted with clay. The ovens are pyrometrically controlled, one pyrometer being placed in the front and one in the back of the furnace.

The oven is fired rather slowly at first, and then the firing is increased at such a rate that in about two days time the castings are at annealing temperature.

(Continued on Page 28)





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## MALLEABLE IRON INDUSTRY

(Continued from Page 20)

The annealing temperature varies in different plants from 1550° F. to 1700° F. The oven is maintained at this temperature for from 40 to 60 hours. At the end of this period the temperature is lowered at about 8 to 10° F. per hour, until the temperature is around 1200° F. The oven doors are then taken off, the stands removed, and the castings shaken out as soon as they are cool enough to handle.

During the annealing period the brittle hard iron castings, which are white in fracture, are converted into soft ductile castings which have a black fracture. The black fracture is the result of the precipitation of free carbon, known as temper carbon. The castings are now composed of ferrite and temper carbon, and perhaps some pearlite, which is a combined form of iron.

The periodic type of annealing oven to which the above description applies is the most common type of oven in use today. Most of the ovens are thoroughly insulated and run under pyrometric control. Figure 3 illustrates the periodic type of annealing oven. This oven has a capacity of 25 tons, and is fired with pulverized coal. As the coal enters the oven it is burned and the products of combustion circulate through the oven, and pass out through flues in the bottom of the oven. The total time required for the malleablizing process requires about seven days.

Some of the large plants make use of a continuous process. The unit consists of a tunnel kiln, which runs from 200 to 300 feet in length. The castings are loaded on short cars which form the bottom of the oven when in the kiln. The castings on passing through the kiln are subjected to a gradation of temperature corresponding to the periodic cycle. With this process it is possible to cut the annealing time to five days.

When the stands are removed from the oven, the castings are taken from the packing material and cleaned in tumbling barrels or by sand blasting. The castings are then sorted, and ground if necessary, inspected carefully, and the defective ones are discarded. Castings that have been warped in the anneal are straightened either by hand, hydraulic press, or drop hammer. The inspected castings are then ready for shipment.

Photographs used in this article, courtesy of the Whiting Corp., and the American Foundry Equipment Co.

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He met her on the stairs,  
It was dark and so he kissed her.  
He said, "Beg pardon, miss,  
I thought it was my sister."  
He held her dainty hand  
Quite glad he hadn't missed her.  
She said, "Pray, don't mention it."  
Ye Gods! It was his sister.